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AREA SOURCE ESTIMATES FOR THE 1985 NAPAP EMISSIONS INVENTORY

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16. ABSTRACT The paper discusses the revised area source methodologies used by the National Acid Precipitation Assessment Program (NAPAP) and EPA's Office of Air Quality Planning and Standards (OAQPS) to generate the emissions estimates found in the 1985 NAPAP Emissions Inventory. The information may be useful to inventory participants, users, and those affected by regulations which may have resulted from information contained in the inventory. It includes an overview of estimation procedures for stationary, mobile, and miscellaneous area source categories. In addition, a more detailed description of the estimation procedures, including general assumptions and references used to obtain input data, is presented for new and revised area sources.

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Inventories	Area Sources	15E
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INTRODUCTION

The National Acid Precipitation Assessment Program (NAPAP) was established by the Acid Precipitation Act of 1980 to coordinate and expand research on problems posed by acid precipitation in and around the U.S. To achieve a fundamental objective of the program, NAPAP's Task Group on Emissions and Controls is working with the U.S. Environmental Protection Agency (EPA) and State air pollution control agencies to develop the 1985 inventory of emissions for anthropogenic sources suspected of contributing to acid deposition processes. EPA's Office of Air Quality Planning and Standards (OAQPS) in Research Triangle Park, North Carolina, maintains a nationwide data base of estimated air pollutant emissions from point and area sources known as the National Emission Data System (NEDS). Area source data files developed from the NEDS and from data voluntarily submitted by State agencies serve as the basis for the 1985 NAPAP area source emission inventory. Each year OAQPS updates emissions estimates utilizing area source files and a series of computer programs with internal quality assurance checks.

For the 1985 emission inventory, NAPAP has requested that States review this methodology and its associated emissions estimates to ensure that they accurately reflect area source emissions for each State. Additionally, NEDS methodologies for a number of source categories have been revised to improve the data for use by NAPAP. Finally, new area source categories with data developed using non-NEDS methodologies have been included to improve the 1985 inventory. This methodology has been documented in a draft report which is currently under State review.[1]

This paper provides State officials and other users of the NAPAP inventory with a general understanding of the revisions being made to estimation procedures used by NAPAP and OAQPS to generate 1985 emissions estimates for area source categories. For each methodology presented, generation of activity level estimates and emission factors necessary to calculate emissions are discussed.

OVERVIEW OF EMISSIONS ESTIMATION

For this paper, area sources are grouped into five categories based on similarities in emission estimation procedures. The area groupings are Stationary Fuel Combustion, Mobile Sources, Solid Waste Disposal, Miscellaneous Area Sources, and Additional Area Sources. The Miscellaneous Area Sources category is a collection of NEDS area source categories which are unrelated to the first three major categories. Additional Area Sources include new area sources not defined in NEDS for which methodologies have been developed specifically for the 1985 NAPAP Emissions Inventory.

Emissions are estimated by area source category at the county level for each of the approximately 3100 counties in the U.S. In general, the format used to calculate county emissions for each methodology falls into one of two groups. Emission estimates of most area source categories for NEDS are calculated using the equation:

County Estimated Emissions	=	County Activity Level	x	Emission Factor	(1)

County activity levels are calculated with algorithms that utilize related information published mainly by other Federal agencies, supplemented by special data developed by EPA specifically for area source inventories. For some area source categories, data such as State level stationary source fuel consumption are adjusted to account for point source activities and then allocated to the county level using related data such as employment, population, and miscellaneous geographic or economic data. County totals are then summed and normalized with published State level data. Area source emissions estimates for one or more of five pollutants (particulates, SO_x, NO_x, VOC, and CO) are then derived for each source category by multiplying the activity level by the appropriate emission factor from the NEDS area source emission factor file. For most source categories the same emissions factors are used nationwide. The emission factors originally obtained from EPA report AP-42 are adjusted to reflect current control efficiencies and operating conditions.[2] More specific factors are used in emissions calculations for highway motor vehicles, fugitive dust, and other selected categories for which data are available to develop more site-specific emission factors.

Many of the new methodologies in the Additional Area Sources category are organized differently because they utilize existing published emissions data rather than activity level data. These methodologies calculate emissions based on the equation:

County Estimated Emissions	=	Total National Emissions	x	County Allocation Factor	-	County Point Source Emissions	(2)

For these area source categories, emissions estimates for certain NEDS point sources are subtracted from the published total emissions that have been allocated to the county level. County totals are then summed and normalized to eliminate negative values. The resulting estimates are included in the 1985 NAPAP Emissions Inventory.

AREA SOURCE METHODOLOGIES

In the following section, a general description of estimation methodologies for each area source is outlined by major groups. For source emissions where activity levels are calculated using an algorithm, dependent variables and sources are listed. All other allocation factors and emissions data sources are also identified. Emission factors are obtained from AP-42 unless noted otherwise.[2]

Stationary Sources

Stationary sources are divided into three major categories: Residential Fuel, Commercial and Institutional Fuel, and Industrial Fuel. Each category is further subdivided into fuel types for which consumption data are estimated using algorithms and published fuel use data.[3,4] Consumption estimates used as the measure of activity levels are then multiplied by emission factors from AP-42 to obtain emissions estimates.

Residential Fuel. The residential fuel category includes estimated emissions for residential activities which utilize fuel for water heating, space heating, and cooking. Emissions contributed by residential fuel consumption are calculated for six fuel types using an algorithm that considers heating degree days, number of residential units, and median number of rooms per dwelling. For each fuel type, the estimated county activity levels are then normalized to be consistent with published State data.

Commercial/Institutional Fuel. Area source emissions from fuel use by commercial and institutional sources include emissions from hospitals, hotels, laundries, schools, and universities. County consumption data for five fuel types are estimated for the five identified commercial subcategories. Algorithms are based on data such as employment, climatological data, population, enrollment, and number of beds per institution. Total fuel consumption is distributed by the subcategories to each fuel type, using housing data and published State fuel consumption data. Fuel consumption estimates for the five subcategories are summed and compared with published State fuel totals. If the estimated fuel use exceeds the published State total, county estimates are normalized to agree with the State total. If the estimated fuel use is less than the State total, the difference is added to the estimated subcategory totals and allocated to counties by population.

Industrial Fuel. Emissions for the industrial sector are calculated as follows. First, State level industrial area source fuel consumption estimates are determined by subtracting point source fuel consumption totals from published State totals. Next, the area source fuel use estimates are allocated to counties using county employment data for the manufacturing sector (Standard Industrial Classification groups 20 through 39). These county employment data have been adjusted to exclude employment at point sources and have been weighted by fuel intensity ratios for each two-digit SIC group.

Mobile Sources

Mobile sources which contribute to area source emissions are divided into Highway Vehicles, Off-Highway Vehicles, Railroad Locomotives, Aircraft, and Marine Vessels.

Highway Vehicles. Highway vehicles are disaggregated into four categories on the basis of use and gross vehicle weight for the purpose of calculating fuel consumption. The categories include light duty gasoline vehicles, light duty gasoline trucks, heavy diesel vehicles, and heavy duty gasoline vehicles. NEDS utilizes vehicle registration data and published average miles travelled by some vehicle types to allocate to the county level. Fuel consumption, average fuel efficiencies, and mileage by road type in each county are used to determine vehicle miles travelled (VMT) for three road classes: limited access roads, rural roads and urban roads.[4,5] This allocation separates the total VMT for a county into road speed classes. Emission factors obtained from the execution of EPA's MOBILE3 model are applied so to determine emissions for each vehicle type and speed class.[5]

Off-Highway Vehicles. Emissions from off-highway vehicles are generated by activities of gasoline and diesel vehicles which do not utilize road systems. Vehicles contributing to off-highway emissions are divided into six general categories: farm equipment, construction equipment, industrial equipment, motorcycles, lawn and garden equipment, and snowmobiles. Consumption is estimated separately for each category by either apportioning national fuel consumption to counties on the basis of employment, population, etc., or by calculating county or State totals by applying fuel consumption rates to average usage figures and equipment populations.[6] Estimated fuel use is normalized to agree with published State totals, where available. Emission factors from AP-42 are weighted for each category using equipment populations. Off-highway motorcycle emissions are computed using data representing uncontrolled emissions in the MOBILE2 model.[7]

Railroad Locomotives. The activity level for railroad locomotive use of distillate oil is calculated by allocating published State consumption data to the county level based on county population statistics.[3] Resulting consumption data are used with AP-42 emission factors to determine emissions.

Aircraft. Activity level estimates for aircraft (private, military, and commercial) utilize aircraft operations data and aircraft type populations to estimate number of landing/takeoff cycles (LTOs) in each group.[3] Emission factors from AP-42, defined as emissions per LTO, are multiplied by LTOs to obtain emissions.

Marine Vessels. Estimation of marine vessel consumption for distillate oil, residual oil, and gasoline is based on published consumption data.[3] Distillate oil and residual oil used by vessels are allocated to counties using data on the number of vessels visiting major ports and tonnage of cargo handled in each port. Gasoline vessel consumption computations utilize inboard and outboard motorboat registrations and published average consumption data to determine consumption. County allocation is based on inland water area, coastline, and the number of months suitable for recreational boating. Emission factors from AP-42 are multiplied by consumption data to obtain emissions estimates.

Solid Waste Disposal

The solid waste disposal category includes on-site refuse disposal activities by residential, commercial/institutional, and industrial sectors. Solid waste generation for open burning and on-site incineration is calculated using population data, per capita generation factors, and information from related point source categories. Activity levels are multiplied by specific emission factors from AP-42 to obtain emissions estimates.

Miscellaneous Area Sources

NEDS area sources which are not defined by the other categories are compiled in the Miscellaneous Area Sources category. Miscellaneous area sources include: Gasoline Marketed, Organic Solvent Consumption, Unpaved Road Travel, Unpaved Air Strip Use, Forest Wildfires, Managed Burning, Agricultural Burning, and Structural Fires.

In brief, activity levels, estimated using category specific data, are multiplied by emission factors to obtain emissions estimates. Activity levels for Gasoline Marketed are determined using county retail service station sales data.[3] Activity levels for Organic Solvent Consumption are determined by allocating national estimates of organic solvent consumption by end use category to counties according to manufacturing employment data or population.[3] The Unpaved Road Travel category utilizes unpaved road miles and rural population as the basis of county allocation.[8] Unpaved Airstrip Use is estimated by landing/takeoff (LTO) cycles occurring in the county.[8] Number of acres burned and fuel loading factors are used as activity levels for Forest Wildfires, Managed Burning, and Agricultural Burning categories.[9] The Structural Fires category utilizes the number of building fires, allocated to the county level by population.

Additional Area Sources

The 1985 NAPAP Emissions Inventory will provide detailed county level VOC emission estimates for additional area sources which previously have not been included in the NEDS area source categories. In this section, methods have been developed for many categories which have been traditionally considered point source categories such as Bakeries and Synthetic Fiber Manufacturing. These categories were included to reconcile the difference between the total emissions reported in the National Air Pollutant Emissions Estimates 1940-1984 and emissions already accounted for by the NEDS point source data files.[10] The remaining categories such as Publicly-Owned Treatment Works (POTWs) and Hazardous Waste Treatment Storage and Disposal Facilities (TSDFs) have been included due to the difficulty in measurement of emissions from a specific point (e.g., aeration basin).

Methodologies are discussed under New Methodologies for the following area sources: POTWs; Hazardous Waste TSDFs; Fugitive Emissions from Synthetic Organic Chemical Manufacturing; Bulk Terminals and Bulk Plants; Fugitive Emissions from Petroleum Refining Operations: Process Emissions from Bakeries, Pharmaceutical, and Synthetic-Fiber Manufacturing; Crude Oil and Natural Gas Production Fields; and Cutback Asphalt Paving Operations. For most categories, national published VOC emissions estimates from recent studies are allocated to the county level using category-specific data such as industrial flow and employment.

NEW METHODOLOGIES

This section describes the general methodologies and assumptions for area source emissions estimation procedures developed or revised to enhance the 1985 NAPAP Emissions Inventory. Area source methodologies discussed include: Highway Vehicles - Heavy Duty Diesel Vehicles; POTWs; Hazardous Waste TSDFs; Fugitive Emissions from Synthetic Organic Chemical Manufacturing; Bulk Terminals and Bulk Plants; Fugitive Emissions from Petroleum Refining Operations; Process Emissions from Bakeries, Pharmaceutical, and Synthetic-fiber Manufacturing; Crude Oil and Natural Gas Production Fields; and Cutback Asphalt Paving Operations. For Highway Vehicles, the existing methodology was revised. For the other source categories, new techniques were developed.

Highway Vehicles: Heavy Duty Diesel Vehicles (HDDVs)

NEDS disaggregates motor vehicles into four categories on the basis of use and gross vehicle weight for the purpose of calculating emissions: light duty gasoline vehicles, light duty gasoline trucks, and heavy duty gasoline and diesel vehicle categories.[3] The heavy duty vehicle categories include trucks and buses weighing more than 8500 lb (18700 kg). The new methodology developed for the 1985 inventory uses estimated county level fuel consumption and average fuel efficiencies to estimate total vehicle miles travelled (VMT) for each vehicle class.[5] These totals are then distributed into classes of average speed based on road type. VMT for each speed class is estimated using road mileages for the following road types:

Limited Access Roads	Rural and Urban Interstate
55 mph (90 km/h)	Rural and Urban Other Principal Arterials
	Other Freeways and Expressways
	Rural and Urban Minor Arterials
Rural Roads	Rural Major Collector
45 mph (75 km/h)	Rural Minor Collector
	Rural Local
Urban Roads	Urban Collector
19.6 mph (32 km/h)	Urban Local

Previously, NEDS estimated only a breakdown of VMT by vehicle category into two speed classes (19.6 and 45 mph), based on county rural and urban population data.

The methodology for determining diesel fuel consumption of heavy duty vehicles on a county basis differs significantly from the methods used for other vehicle types because much of the HDDV fuel consumption is accrued outside the county of registration. Two estimates are calculated to reflect consumption based on long- and short-range travel.

By this method State diesel fuel consumption data for trucks weighing at least 8500 lb (18700 kg) are allocated to the county level using total, out-of-state, and local VMT extracted from the Truck Inventory and Use Survey (TIUS).[11] The TIUS contains the results of a statistical sample of truck characteristics and operational behavior.

Total VMT = Annual Miles X Stratum Expansion Factor

Long-Range VMT = Annual Miles X Percent of Travel Outside State X Stratum Expansion Factor

Short-Range VMT = Total VMT - Long-Range VMT

Stratum expansion factors expand TIUS sample data to State truck population totals.

State long-range totals are summed to form the national HDDV long-range VMT pool. The national long-range VMT pool is first allocated to the State level according to the fraction of the total State mileage of the National Network located within each State. National Network mileage on a county basis is not available. The National Network is a set of highways on which large trucks are ensured travel rights. Since the National Network is a subset of the Federal Aid Primary (FAP) System, and data on FAP county mileage are available by road type, State totals of National Network mileages are allocated to counties on the basis of county mileage of each of the major FAP road types: Interstate, Major Arterials, and Freeways.

Short-range VMT is allocated to the county level on the basis of truck registrations. Short- and long-range VMT are then totalled for each county and divided by the average fuel efficiency (miles per gallon) to obtain county fuel consumption by HDDV.

Since the behavior of HDDV differs significantly from that of other vehicle types, VMT is allocated differently to speed classes (limited access, urban, and rural). Each county's HDDV long-range VMT is assumed to occur on limited access roads; short-range HDDV VMT is divided equally between rural and urban roads.

Emissions for each specific vehicle speed class are computed using MOBILE3, a computer model which is designed to simulate vehicle behavior under a range of conditions.[5] For each county, scenario inputs include county altitude, vehicle start-mode, county temperature, and impact of inspection/maintenance programs.

Publicly Owned Treatment Works (POTWs)

The published national VOC emissions estimate for the worst case scenario for unacclimated treatment systems was selected for use in the calculation of county VOC emissions in the 1985 NAPAP Emissions Inventory.[1] Because research on VOC concentrations in POTW influents and effluents implies that the removal

mechanisms for these pollutants are relatively constant and only a percentage of incremental loadings is removed by POTWs, the national VOC emissions estimate for unacclimated treatment systems is allocated to the county level based on the percentage of industrial flow per county. To eliminate double counting, emissions accounted for by point source categories are subtracted from the national emissions estimate before county allocation. The total VOC emissions from POTWs for the nation are estimated in the EPA Domestic Sewage Study.[12] Industrial flow data are readily available from the EPA Office of Municipal Pollution Control biennial assessment of the wastewater treatment needs in the U.S.[13]

Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDFs)

National VOC emissions estimates are developed using facility specific process descriptions, waste characterization and quantities, and process specific emission factors.[1] Emissions from each TSDF in the U.S. are summed at the county level to form the national emissions estimates. Emissions at a TSDF are defined as the total VOCs emitted by all plant processes; emissions from each plant process are calculated as the product of the quantity of a specific waste handled and a process-specific emission factor. Waste handling data are obtained from the 1985 Hazardous Waste Data Management System (HWDMS).[14] Process-specific emission factors are obtained from the Background Information Documents for TSDFs.[15] To eliminate double counting, emissions accounted for by point source categories are subtracted from the county level emissions estimate.

Fugitive Emissions from Synthetic Organic Chemical Manufacturing

The fugitive emissions from synthetic organic chemical manufacturing are estimated using OAQPS estimates of national emissions for the manufacture of petrochemicals.[1,10] Assuming that the potential for fugitive emissions (i.e., the number of pumps, valves, flanges, etc.) increases with the number of employees, the national VOC emissions are allocated to specific counties based on the ratio of the county to national employment in SIC category 2869 obtained from the Bureau of Census' County Business Patterns.[16]

Currently, NEDS point source entries under several Source Classification Codes (SCCs) which already account for a portion of fugitive emissions are 3-01-800 (General Processes-Fugitive Leaks), 3-01-888 (Fugitive Emissions-Not Classified), and many chemical production-specific SCCs designated as Fugitive Emissions: General. The total VOC emissions for these SCCs are totalled by county and then subtracted from the national emissions estimates. If a county has greater point source VOC emissions reported in NEDS than the overall emission level allocated from the national fugitive VOC emissions estimate, it is assumed that the fugitive VOC emissions for area source emission levels are adequately represented by point source VOC emissions data reported in NEDS. The national sum of all negative emissions is reallocated to the counties exhibiting positive emission levels based on the relative proportion of employment for SIC category 2869 located in each county.

Bulk Terminals and Bulk Plants

Current methodology uses national VOC emissions estimates for gasoline bulk terminals and bulk plants developed by the OAQPS based on total annual throughput.[1] Assuming control is neglibile at bulk plants, the national VOC emissions estimate is allocated to the county level based on the county employment in SIC category 5171 taken from the Bureau of Census' County Business Patterns.[16]

The VOC county emissions totals for the point source data files for SCC 4-04-001 (Bulk Terminals) and SCC 4-04-002 (Bulk Plants) are then subtracted from the portion of the corresponding national VOC emissions estimate. Negative emissions are reallocated to the counties as previously described using employment data for SIC category 5171.

Fugitive Emissions from Petroleum Refinery Operations

Annual VOC emissions estimates for petroleum refinery operations have been developed by the OAQPS using capacity or production data.[1] Assuming that these national VOC emissions estimates represent the sum of the fugitive and point source emissions for refinery processes, fugitive emissions are quantified by subtracting the total county point source VOC emissions of SCC categories 3-06-004 through 3-06-88 (Refinery Processes, excluding process heaters and catalytic cracking units) from the total emissions estimated for petroleum refinery processes in each county. National emissions data are allocated to each county based on refinery capacity data published in DOE's Petroleum Supply Annual.[17] Negative emissions are reallocated to counties as previously described using refinery capacity data.

Process Emissions from Bakeries

Annual VOC emissions estimates from bakery operations developed by the OAQPS are allocated to each county based on the county employment census data for SIC categories 2051 and 2052 available in the Bureau of Census' County Business Patterns.[1,16] Total county point source VOC emissions for SCC 3-02-032 (Bakeries) listed in NEDS are subtracted from the national VOC emissions estimate allocated to each county. Negative emissions are reallocated to counties as previously described using employment data for SIC categories 2051 and 2052.

Process Emissions from Pharmaceutical Manufacturing

Annual VOC emissions estimates from pharmaceutical manufacturing operations developed by the OAQPS are allocated to specific counties based on the county employment census data for SIC category 2834 obtained from the Bureau of Census' County Business Patterns.[1,16] Total point source VOC emissions for SCC 3-01-060 (Pharmaceutical Preparations) listed in NEDS for each county are subtracted from the national VOC emissions estimate allocated to each county. Negative emissions are reallocated to counties as previously described using employment data for SIC category 2834.

Process Emissions from Synthetic-Fibers Manufacturing

The annual VOC emissions estimate from synthetic-fibers manufacturing operations developed by the OAQPS is allocated to the county level based on the combined county employment for SIC categories 2823 and 2824 obtained from the Bureau of Census' County Business Patterns.[1,16] NEDS point source VOC emissions for SCC 3-01-024 (Synthetic Organic Fiber Production) and 3-01-025 (Cellulosic Fiber Production) for each county are then subtracted from the national emissions estimate allocated to each county. Negative emissions are reallocated to counties as previously described using employment data for SIC categories 2823 and 2824.

Crude Oil and Natural Gas Production Fields

Annual VOC emissions estimates for crude oil and natural gas production developed by the OAQPS are distributed to the State level in proportion to the volume of State annual production available in the Petroleum Supply Annual and the Oil and Gas Journal.[1,17,18] The state VOC emissions are then allocated to specific counties based on county employment for SIC category 1310 which is found in the Bureau of Census' County Business Patterns.[16] VOC emissions for these sources currently accounted for in the total point source VOC emissions listed in NEDS point source data files for SCC 3-10-001 (Crude Oil Production) and SCC 3-10-002 (Natural Gas Production) are subtracted from the estimates. Negative emissions are reallocated to counties as previously described using employment data for SIC category 1310.

Cutback Asphalt Paving Operations

State VOC emissions for cutback asphalt paving operations are calculated by multiplying the activity level, measured in total quantity of cutback asphalt sales, by an emission factor.[1] The cutback asphalt sales information provided by The Asphalt Institute is organized by state and district.[19] The state emissions totals are then allocated to specific counties based on employment for SIC category 1611 obtained from the Bureau of Census' County Business Patterns.[16] A VOC emission factor based on the weight of asphalt used has been established by the OAQPS which assumes complete evaporation of all organic solvents used in paving operations.

SUMMARY AND CONCLUSIONS

Considerable time and effort have been spent on the development of area source methodologies to accurately estimate emissions of pollutant species thought to contribute to acid rain deposition. The primary focus has been on area sources known to generate significant emissions of pollutants resulting from stationary fuel use by residential, commercial, and industrial sectors; mobile source fuel use; and organic solvent consumption. Methods were determined to accurately measure the activity level and calculate appropriate emission factors. Later, methodologies for fugitive emissions from other anthropogenic activities were added. Most recently, methodologies of new area sources, more traditionally considered as point sources, have been added to supplement emissions source data.

For the 1985 NAPAP Emissions Inventory, area source methodology documentation was compiled into a draft report and distributed to State air pollution control officials and other inventory participants to solicit comments for improvements on all area source methodologies. Resulting comments have been incorporated as much as possible into the present area source methodology in order to effect the 1985 inventory. Suggestions concerning the identification of new area source categories or requiring more intense research have been gratefully accepted and will be used to improve the emission estimation procedures used in future NAPAP emissions inventories.

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